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Appl. No.	: **09/633,760**
Applicant(s)	: **WEINSHALL et al.**
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Title: **STRAPDOWN SYSTEM FOR THREE-DIMENSIONAL RECONSTRUCTION**

Mail Stop: **APPEAL BRIEF - PATENTS**
Commissioner for Patents
Alexandria, VA 22313-1450

APPEAL UNDER 37 CFR 41.37

Sir:

This is an appeal from the decision of the Examiner dated 6 January 2005, finally rejecting claims 1-12 and 17-26 of the subject application.

This paper includes (each beginning on a separate sheet):

1. **Appeal Brief;**
2. **Claims Appendix; and**
3. **Credit card authorization in the amount of $500.**

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APPEAL BRIEF

I. REAL PARTY IN INTEREST

The above-identified application is assigned, in its entirety, to Philips Electronics North America Corporation.

II. RELATED APPEALS AND INTERFERENCES

Appellant is not aware of any co-pending appeal or interference which will directly affect or be directly affected by or have any bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 13-16 are canceled.

Claims 1-12 and 17-26 are pending in the application.

Claims 1-4, 6, and 11-12 stand rejected by the Examiner under 35 U.S.C. 102(b).

Claims 5, 7-10, and 17-26 stand rejected by the Examiner under 35 U.S.C. 103(a).

These rejected claims are the subject of this appeal.

IV. STATUS OF AMENDMENTS

No amendments were filed subsequent to the final rejection in the Office Action dated 6 January 2005. A reply to the final rejection was filed on 16 February 2005.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The invention provides a method and system for determining a location of an object in a scene with minimal calibration information (page 2, lines 2-12). A jig, or strapdown system, affixes two cameras (100, 105) behind a screen (135) with an aperture (150, 155) for each camera (FIGs. 1A-1C), wherein the cameras have a common field of view through the apertures, albeit from different positions. Each aperture is at least four sided, and visible within each camera's field of view, thereby providing at least four points (the vertices of each aperture, FIG. 1D) for each camera that lie in a common plane (the plane of the screen 135).

Two techniques are detailed for calibrating the system to facilitate the determination of the location of an object within the cameras' fields of view (page 2, line 13 through page 3, line 6). Other techniques are also presented (see page 11, lines 14-21). In a first example embodiment, optical centers, corresponding to a location of a pinhole of equivalent pinhole cameras, are determined and subsequently used to determine the object's location, assuming that the image of the apertures are substantially perpendicular to the screen 135 (page 4, lines 5-18; also page 11, lines 8-10 and page 12, lines 8-22). In a second example embodiment, two reference markers at known distances from the plane of the screen are placed in the cameras' fields of view, via, for example, a movable boom 140 that is illustrated in FIG. 1A, so that the depth of the object relative to the screen may also be determined (page 12, line 23 through page 16, line 2).

In an alternative embodiment, a background screen is provided that includes four reference markers that are within the field of view of the cameras (page 11, line 22 through page 12 line 7, and FIGs. 5 and 6).

As claimed in independent claim 1, the invention comprises a method of determining a position of an unknown point in space using at least two cameras (100, 105 of FIG.1) aimed to have a substantially overlapping field of view (page 9, lines 16-20), comprising:

generating in each of the cameras an image corresponding to at least four points lying in a reference plane (page 10, line 22 through page 11, line 2), the reference plane (137) being common to the respective images (views within 150, 155) of the cameras (100, 105);

calculating a planar projective transform that maps the images of the at least four points to a reference frame, the reference frame being a projection of the reference plane (page12, lines 2-7);

generating, in each of the cameras, images of at least two calibration markers whose positions relative to the reference plane are known and an image of an unknown point (page 12, lines 8-15);

for each of the images of the at least two calibration markers and the image of an unknown point, applying the transform to define respective points in the reference frame (page 12, lines 16-19); and

computing at least a distance of the unknown point from the reference plane responsively to the points defined in the reference frame for the markers and the unknown point (Equation 1, detailed at page 14, line 8 through page 16, line 2).

As claimed in dependent claim 5, the invention comprises a method as in claim 1, wherein generating the image of the calibration markers includes positioning the calibration markers by extending a boom with the markers (page 10, lines 5-10).

As claimed in independent claim 7, the invention comprises a strap-down three-dimensional reconstruction system (FIGs. 1A-1C), comprising:

a jig (110) supporting at least two cameras (100, 105) (page 5, lines 19-23);

the jig having a structure (140) to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras (page 6, lines 2-5); and

the jig also supporting at least four reference markers (21-24) in a visual field (155) of each of the at least two cameras, all of the reference markers lying in a common plane (137) (page 5, line 23 through page 6, line 2).

As claimed in dependent claim 9, the invention comprises a system as in claim 7, wherein the four reference markers are projected onto a screen (FIG. 2; page 16, lines 18-23).

As claimed in independent claim 11, the invention comprises a method of determining a position of an unknown point in space using at least two cameras (100, 105) aimed to have a substantially overlapping field of view (page 9, lines 16-20), comprising the steps of,

generating in each of the cameras an image corresponding to at least four points lying in a reference plane (page 10, line 22 through page 11, line 2), the reference plane (137) being common to the respective images (views within 150, 155) of the cameras (100, 105);

calculating a planar projective transform that maps the images of the at least four points to a reference frame, the reference frame being a projection of the reference plane (page12, lines 2-7);

generating, in each of the cameras, images of at least two calibration markers whose positions relative to the reference plane are known (page 12, lines 8-11);

transforming, by the planar projective transform, each of the images of calibration markers (page 12, lines 16-19);

computing optical centers of the cameras responsively to a result of the step of transforming (page 12, lines 11-15);

generating in each of the cameras an image of an unknown point and calculating a position of the unknown point responsively to a result of the step of computing (page 12, lines 16-22).

As claimed in independent claim 17, the invention comprises a system comprising:

a support (110) that is configured to support at least two optical devices (100, 105),

a screen (135) that includes at least two apertures (150, 155), the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices (page 9, lines 14-23), and

a processor (305) that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal image of the screen (page 16, lines 3-10).

As claimed in independent claim 24, the invention comprises a method of determining a location of an object, comprising:

providing a screen (135) with at least two apertures (150, 155),

providing a substantially orthogonal image of the screen with the at least two apertures (page 11, lines 8-10),

providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture (page 10, line 22 through page 11, line 2), and

determining the location of the object relative to the screen based on the image of the screen and the at least two images (page 11, lines 2-7).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1-4, 6, and 11-12 stand rejected under 35 U.S.C. 102(b) over Weinshall et al. (*From Ordinal to Euclidean Reconstruction with Partial Scene Calibration*, hereinafter Weinshall).

Claims 5, 7-8, 10, and 17-25 stand rejected under 35 U.S.C. 103(a) over Weinshall and Wilson et al. (USP 5,386,299, hereinafter Wilson).

Claim 9 stands rejected under 35 U.S.C. 103(a) over Weinshall, Wilson, and Proesmans et al. (USP 6,510,244, hereinafter Proesmans).

VII. ARGUMENT

Claims 1-4, 6, and 11-12 stand rejected under 35 U.S.C. 102(b) over Weinshall

Claims 1-4 and 6

Claim 1, upon which claims 2-6 depend, specifically claims a method of determining a position of an unknown point in space using at least two cameras aimed to have a substantially overlapping field of view, that includes generating in each of the cameras an image corresponding to at least four points lying in a reference plane, the reference plane being common to the respective images of the cameras.

The final Office action asserts that Weinshall's section 2.1 teaches a reference plane that is common to the images of cameras. The applicants respectfully note, however, that Weinshall's section 2.1 discusses how the shape of an object can be represented on a reference plane, but does not address cameras having a field of view that includes points on this reference plane. Instead, Weinshall specifically teaches that the reference plane that contains the representation of the object can be projected onto each camera's image plane:

> "we break down the projection into 2 operations: the projection of the 3D world onto a 2D reference plane Π through the focal-point P_t, followed by a 2D projective transformation (homography) which ***maps the reference plane Π to the image plane of camera t***" (Weinshall, page 210, third full paragraph).

Because Weinshall specifically teaches mapping a reference plane to the image plane of each camera, whereas the applicants teach and claim generating an image in each camera an image corresponding to at least four point lying in a reference plane that is common to each camera, the applicants respectfully maintain that claims 1-6 are patentable under 35 U.S.C. 102(b) over Weinshall.

Claims 11-12

Claim 11, upon which claim 12 depends, similarly claims a method of determining a position of an unknown point in space that includes generating in each of the cameras an image corresponding to at least four points lying in a reference plane, the reference plane being common to the respective images of the cameras.

As noted above, Weinshall teaches representing an object in a reference plane, followed by a transformation that maps the reference plane to the image plane of each camera, and does not teach generating in each of the cameras an image corresponding to at least four points lying in a reference plane that is common to each camera.

Because Weinshall specifically teaches mapping a reference plane to the image plane of each camera, whereas the applicants teach and claim generating an image in each camera corresponding to at least four point lying in a reference plane that is common to each camera, the applicants respectfully maintain that claims 11 and 12 are patentable under 35 U.S.C. 102(b) over Weinshall.

Claims 5, 7-8, 10, and 17-25 stand rejected under 35 U.S.C. 103(a) over Weinshall and Wilson

Claim 5

Claim 5 is dependent upon claim 1, discussed above with regard to Weinshall. The applicants respectfully maintain that claim 5 is patentable over Weinshall based on the comments above regarding claim 1.

Further, the applicants respectfully maintain that claim 5 is patentable over Weinshall and Wilson, because neither Weinshall nor Wilson, individually or collectively, teach or

suggest positioning at least two calibration markers in overlapping field of views of the cameras by extending a boom with the markers.

The final Office action asserts that Wilson teaches extending a boom with markers, at column 3, lines 29-38. The applicants respectfully note, however, that Wilson's cammed wheel 52 is not a boom, per se, and that each of Wilson's two cammed wheels 52 provides different sets of calibration markers to each of the two cameras 20, 24, because these cameras 20, 24 do not have an overlapping field of view. The applicants respectfully maintain that one of ordinary skill in the art, given Wilson's teaching of different cammed calibration markers for each of two cameras, would not be lead to the applicants' teaching of a boom that provides at least two calibration markers in overlapping fields of view of the cameras.

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest positioning at least two calibration markers in overlapping field of views of the cameras by extending a boom with the markers, as claimed in claim 5, the applicants respectfully maintain that claim 5 is patentable under 35 U.S.C. 103(a) over Weinshall and Wilson.

Claims 7-8 and 10

Claim 7, upon which claims 8-10 depend, claims a strap-down three-dimensional reconstruction system, comprising a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane.

The Office action acknowledges that Weinshall does not teach a jig having a structure to support the calibration markers or the reference markers, and relies upon Wilson for this teaching. The Office action cites Wilson, column 3, lines 29-38 for teaching the applicants' claimed jig; the cited text follows:

> "The apparatus or calibration device 12-1 includes a moveable member 52 which is moveable between first and second positions relative to the optical axis 54 of the front camera 20 as shown in FIG. 3. When in the first position, the moveable member 52 has a first reference member 52-1 which is positioned relative to the optical axis 54 of the front camera 20. In the embodiment described, the first reference member 52-1 is a black member, although for different applications, the colors used for the first and second reference members may change." (Wilson, column 3, lines 29-38.)

As can be seen, the cited text does not teach a jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras, and does not teach that the jig supports at least four reference markers in a visual field of each of the at least two cameras, and does not teach that the jig provides all of the reference markers in a common plane. The final Office action asserts (at page 4, last paragraph) that "it would have been obvious ... to have modified the calibration and reference markers disclosed by Weinshall to include a structure to support the cameras and markers, as taught by Wilson" to reach the applicants' claimed invention, but provides no basis for this assertion. Further, assuming in argument that one of skill in the art were to combine Weinshall and Wilson, the applicants note that neither Weinshall nor Wilson teaches a configuration of cameras and markers such that the markers are in a common visual field of the cameras, and neither Weinshall nor Wilson teaches providing such markers in a common plane.

Because neither Weinshall nor Wilson, individually or collectively teach or suggest a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane, as claimed by the applicants, the applicants respectfully maintain that claims 7, 8, and 10 are patentable under 35 U.S.C. 103(a) over Weinshall and Wilson.

Claims 17-23

Claim 17, upon which claims 18-23 depend, claims a system that includes a support that is configured to support at least two optical devices, a screen that includes at least two apertures, the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices, and a processor that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal image of the screen.

The final Office action asserts that "arguments analogous to those presented above for claims 1, 7, and 8 are applicable to claims 17 and 24" (Office action, page 5, third paragraph). The applicants respectfully maintain that claim 17 is patentable over Weinshall and Wilson based on the arguments presented above with regard to claims 1 and 7.

In the alternative, the applicants respectfully note that neither Weinshall nor Wilson teaches a screen that includes at least two apertures; that neither Weinshall nor Wilson teaches the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices; and that neither Weinshall nor Wilson teaches a processor that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal image of the screen.

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest a system that includes a support that is configured to support at least two optical devices, a screen that includes at least two apertures, the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices, and a processor that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal image of the screen, as claimed in claim 17, the applicants respectfully maintain that claims 17-23 are patentable under 35 U.S.C. 103(a) over Weinshall and Wilson.

Claims 24-26

Claim 24, upon which claims 25-26 depend, claims a method of determining a location of an object, that includes providing a screen with at least two apertures, providing a substantially orthogonal image of the screen with the at least two apertures, providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture, and determining the location of the object relative to the screen based on the image of the screen and the at least two images.

As noted above, the final Office action relies upon the rejections of claims 1, 7, and 8 to support the rejection of claim 24. The applicants respectfully maintain that claims 24-26 are patentable based on the arguments presented above with regard to claims 1 and 7.

In the alternative, the applicants respectfully note that neither Weinshall nor Wilson teaches providing a screen with at least two apertures; neither Weinshall nor Wilson teaches providing a substantially orthogonal image of the screen with the at least two apertures; and neither Weinshall nor Wilson teaches providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture.

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest a method of determining a location of an object, that includes providing a screen with at least two apertures, providing a substantially orthogonal image of the screen with the at least two apertures, providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture, and determining the location of the object relative to the screen based on the image of the screen and the at least two images, as claimed in claim 24, the applicants respectfully maintain that claims 24-26 are patentable under 35 U.S.C. 103(a) over Weinshall and Wilson.

Claim 9 stands rejected under 35 U.S.C. 103(a) over Weinshall, Wilson, and Proesmans

Claim 9 is dependent upon claim 7, discussed above with regard to claim 7 and Weinshall and Wilson.

Claim 9 claims a strap-down three-dimensional reconstruction system, comprising: a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane, wherein the four reference markers are projected onto a screen.

The final Office action acknowledges that neither Weinshall nor Wilson teaches projecting reference markers on a screen, and relies upon Proesmans for this teaching. The applicants acknowledge that Proesmans teaching a projection of points to a screen, but respectfully note that the combination of Weinshall, Wilson, and Proesmans does not teach the elements of claim 9. Proesmans does not rectify the deficiencies of Weinshall and Wilson in teaching the elements of claim 7, upon which claim 9 depends.

Because neither Weinshall, nor Wilson, nor Proesmans, individually or collectively teach or suggest a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane, as claimed by the applicants, the applicants respectfully maintain that claim 9 is patentable under 35 U.S.C. 103(a) over Weinshall, Wilson, and Proesmans.

SUMMARY

Because Weinshall does not teach generating an image in each camera an image corresponding to at least four point lying in a reference plane that is common to each camera, the applicants respectfully request that the Examiner's rejection of claims 1-4 and 6 under 35 U.S.C. 102(b) over Weinshall be reversed by the Board, and the claims be allowed to pass to issue.

Because Weinshall does not teach generating an image in each camera corresponding to at least four point lying in a reference plane that is common to each camera, the applicants respectfully request that the Examiner's rejection of claims 11 and 12 under 35 U.S.C. 102(b) over Weinshall be reversed by the Board, and the claims be allowed to pass to issue..

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest positioning at least two calibration markers in overlapping field of views of the cameras by extending a boom with the markers, the applicants respectfully request that the Examiner's rejection of claim 5 under 35 U.S.C. 103(a) over Weinshall and Wilson be reversed by the Board, and the claim be allowed to pass to issue.

Because neither Weinshall nor Wilson, individually or collectively teach or suggest a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane, the applicants respectfully request that the Examiner's rejection of claims 7-8 and 10 under 35 U.S.C. 103(a) over Weinshall and Wilson be reversed by the Board, and the claims be allowed to pass to issue.

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest a system that includes a support that is configured to support at least two optical devices, a screen that includes at least two apertures, the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices, and a processor that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal

image of the screen, the applicants respectfully request that the Examiner's rejection of claims 17-23 under 35 U.S.C. 103(a) over Weinshall and Wilson be reversed by the Board, and the claims be allowed to pass to issue.

Because neither Weinshall nor Wilson, individually or collectively, teach or suggest a method of determining a location of an object, that includes providing a screen with at least two apertures, providing a substantially orthogonal image of the screen with the at least two apertures, providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture, and determining the location of the object relative to the screen based on the image of the screen and the at least two images, the applicants respectfully request that the Examiner's rejection of claims 24-26 under 35 U.S.C. 103(a) over Weinshall and Wilson be reversed by the Board, and the claims be allowed to pass to issue.

Because neither Weinshall, nor Wilson, nor Proesmans, individually or collectively teach or suggest a jig supporting at least two cameras; the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane, the applicants respectfully request that the Examiner's rejection of claim 9 under 35 U.S.C. 103(a) over Weinshall, Wilson, and Proesmans be reversed by the Board, and the claims be allowed to pass to issue.

Respectfully submitted,

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804-493-0707

CLAIMS APPENDIX

1. A method of determining a position of an unknown point in space using at least two cameras aimed to have a substantially overlapping field of view, comprising:

generating in each of the cameras an image corresponding to at least four points lying in a reference plane, the reference plane being common to the respective images of the cameras;

calculating a planar projective transform that maps the images of the at least four points to a reference frame, the reference frame being a projection of the reference plane;

generating, in each of the cameras, images of at least two calibration markers whose positions relative to the reference plane are known and an image of an unknown point;

for each of the images of the at least two calibration markers and the image of an unknown point, applying the transform to define respective points in the reference frame; and

computing at least a distance of the unknown point from the reference plane responsively to the points defined in the reference frame for the markers and the unknown point.

2. A method as in claim 1, wherein

computing at least the distance of the unknown point includes computing a distance of the unknown point from the reference plane responsively to positions of the calibration markers.

3. A method as in claim 2, wherein

the positions indicate a distance of the calibration markers from the reference plane.

4. A method as in claim 1, wherein

generating the image of the calibration markers includes positioning the calibration markers in the overlapping field of view.

5. A method as in claim 4, wherein

positioning includes extending a boom with the markers.

6. A method as in claim 1, wherein

the position of each calibration markers includes only a distance from the reference plane.

7. A strap-down three-dimensional reconstruction system, comprising:

a jig supporting at least two cameras;

the jig having a structure to support at least two calibration markers in a position to be substantially visible by each of the at least two cameras; and

the jig also supporting at least four reference markers in a visual field of each of the at least two cameras, all of the reference markers lying in a common plane.

8. A system as in claim 7, wherein

the four reference markers are corners of an aperture in a screen of the jig.

9. A system as in claim 7, wherein

the four reference markers are projected onto a screen.

10. A system as in claim 7, further comprising

an image processing computer connected to receive the images from the cameras and programmed to calculate a position of a point visible in each of the cameras responsively to position data corresponding to the calibration markers.

11. A method of determining a position of an unknown point in space using at least two cameras aimed to have a substantially overlapping field of view, comprising the steps of,

generating in each of the cameras an image corresponding to at least four points lying in a reference plane, the reference plane being common to the respective images of the cameras;

calculating a planar projective transform that maps the images of the at least four points to a reference frame, the reference frame being a projection of the reference plane;

generating, in each of the cameras, images of at least two calibration markers whose positions relative to the reference plane are known;

transforming, by the planar projective transform, each of the images of calibration markers;

computing optical centers of the cameras responsively to a result of the step of transforming;

generating in each of the cameras an image of an unknown point and calculating a position of the unknown point responsively to a result of the step of computing.

12. A method as in claim 11, wherein

the step of calculating includes transforming the images of the unknown point using the planar projective transform.

13-16. (Cancelled)

17. A system comprising:

a support that is configured to support at least two optical devices,

a screen that includes at least two apertures, the support being arranged such that a field of view of each of the optical devices includes a corresponding aperture of the at least two apertures and overlaps at least a field of view of at least one other of the at least two optical devices, and

a processor that is configured to determine a relative location of an object based on an image of the object in at least two fields of view and based on a substantially orthogonal image of the screen.

18. The system of claim 17, further comprising:

a structure that is configured to provide one or more calibration markers positioned at two known distances from the screen,

wherein

the processor is further configure to determine a distance of the object from the screen, based on one or more images of the one or more calibration markers at the two known distances from the screen.

19. The system of claim 18, wherein

the structure includes a boom that is deployable to position the one or more calibration markers at the two known distances from the screen.

20. The system of claim 17, wherein

the processor determines the relative location of the object independent of any physical dimensions of the system.

21. The system of claim 17, further including

at least one camera corresponding to the at least one optical device.

22. The system of claim 21, wherein

the processor determines the relative location of the object independent of optical settings of the at least one camera.

23. The system of claim 17, further including

the at least one optical device.

24. A method of determining a location of an object, comprising:

providing a screen with at least two apertures,

providing a substantially orthogonal image of the screen with the at least two apertures,

providing at least two images, each image including a view of edges of a corresponding aperture of the at least two apertures and a view of the object within the edges of the corresponding aperture, and

determining the location of the object relative to the screen based on the image of the screen and the at least two images.

25. A method as claimed in claim 24, further including:

providing at least one image of one or more calibration markers located at two known distances from the screen, and

determining a distance of the object relative to the screen based on the at least one image of the one or more calibration markers at two known distances from the screen.

26. The system of claim 24, wherein

determining the location of the object is independent of physical dimensions related to sources of the at least two images.